Microbial Mats (Part 1 of 2):

[Adapted from *NASA's Investigation of a Microbial Mat Community*]

What is it?

What is life and where does it live? In this activity, students will be introduced to the concept of Microbial Mats with a video and class discussion. Microbial Mats are the earliest biological communities on Earth, and as such, are studied in order to be able to recognize the signs of life on other planets. In the later activity, students will grow their own Microbial Mats.

This activity discusses topics related to National Science Education Standards:

5-LS2-1: *Develop a model to describe the movement of matter among plants, animals, decomposers and the environment.*

- This activity helps students understand that a Microbial Mat is an interdependent ecosystem in which different organisms can only survive because of one another.

Materials (per class):

Equipment, provided by NASA:

- *Stromatolite Explorer* video (available for download at http://microbes.arc.nasa.gov/movie/movie.html)

Equipment, not provided by NASA:

- Projector with screen
- Computer

Materials (per student):

Printables:

- Microbe Worksheet
- *Glossary of Terms (optional)*

Artifact included in this kit:

- Fossilized Stromatolite Sample and Information Sheet

Recommended Speakers from Ames:

Please note that our Speakers Bureau program is voluntary and we cannot guarantee the availability of any speaker. To request a speaker, please visit http://speakers.grc.nasa.gov.

Brad Bebout (Astrobiology)

Oana Marcu (SETI Institute, Astrobiology)

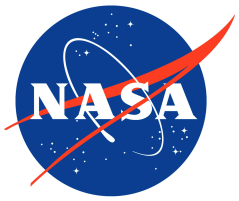
Darlene Lim (Limnology, Underwater Exploration, Astrobiology)

Set-Up Recommendations:

- Download the *Stromatolite Explorer* video from http://microbes.arc.nasa.gov/movie/movie.html
- Prepare copies of **Microbe Worksheet** for students
- *[Optional] Write the **Glossary of Terms** on the board and/or prepare copies for students*

Procedure:

1. Introduce the activity to students with a discussion. Sometimes it may be hard for scientists to tell whether or not something is alive, but scientists have numerous samples right here on Earth! Have you ever noticed green spongy areas around water fountains, drain spouts, or any other area constantly met with water? These green spongy areas are actually a product of a living organism! They are called "biofilms," created by colonies of bacteria. If you don't clean the area, the bacteria will grow and create more biofilm. Bacteria are a type of "microbe," or small, single-celled organisms (called microbes because they're microscopic!) and different microbes working together can form a multi-layered biofilm, called a "Microbial Mat." These Microbial Mats are examples of the earliest forms of biological communities on Earth!
2. Pass out copies of the **Microbes Worksheet**.
3. *[Optional] Pass out copies of the **Glossary of Terms**. We appreciate these terms are advanced, but feel that with proper explanation, students could start to understand their meaning.*
4. Explain to students that they will be viewing a video about Microbial Mats and what you find in them.
5. Before beginning, have students read aloud all of the questions on the worksheet before starting the video. .
6. Show *Stromatolite Explorer* video (run time: 7:00 minutes). As students are watching the video, have them answer all of the questions on their **Microbes Worksheet**. Repeat the video if necessary.
7. After the video, have a small class discussion using the questions from their **Microbes Worksheet** (simple answers are provided here, but students may have different variations of these answers):
    a. From the opening of the video, where do you think Microbial Mats are formed?
        - *They are formed in places with an abundant supply of water.*
    b. What is a Microbial Mat?
        - *A microbial mat is a community of tiny organisms that is less than 5mm thick.*
    c. What kinds of life form inside of a Microbial Mat?



- *Some of the earliest life forms on Earth can be found in a Microbial Mat.*

d. Where do you find **diatoms**?
   - *Diatoms are found at the top of the Microbial Mat.*

e. Beneath **diatoms** are **cyanobacteria**. They are different from how you may think of cells in one big way. What way is that?
   - ***Cyanobacteria*** *do not have a nucleus like other cells.*
   -

f. Fill in the blank: Below the **Cyanobacteria** are the _____ **Sulfur Bacteria** that use Infrared Radiation (heat) to produce a type of photosynthesis.
   - *Purple*

g. What type of bacteria is at the bottom of the Microbial Mat?
   - *Sulfate Reducing Bacteria*

h. Why would a Microbial Mat be an exciting find on another planet?
   - *The microbial mat could be evidence that life formed on other planets. This is one of the main reasons why it is so important to NASA.*

Helpful Resources:

Microbes@NASA
http://microbes.arc.nasa.gov

NASA Astrobiology Institute:
http://astrobiology2.arc.nasa.gov/nai/education-and-outreach/

SpaceRef.com Student's Guide to Astrobiology:
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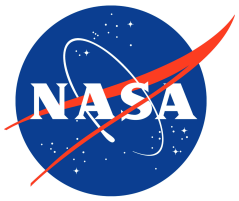


Name: _____

Microbe Worksheet

1. From the opening of the video, where do you think Microbial Mats are formed?

2. What is a Microbial Mat?

3. What kinds of life form inside of a Microbial Mat?

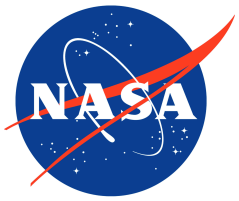
4. Where do you find **Diatoms**?

5. Beneath **Diatoms** are **Cyanobacteria**. They are different from normal cells in one big way. What way is that?

6. Fill in the blank: Below the **Cyanobacteria** are the _____ **Sulfur Bacteria** that use infrared radiation (also known as heat) to produce a type of photosynthesis.

7. What type of bacteria is at the bottom of the Microbial Mat?

8. Why would Microbial Mats be an exciting find on another planet?



Glossary of Terms

Cyanobacteria: Cyanobacteria are microbes that do not have a nucleus (like normal cells). In normal cells, DNA can be found wound tightly inside of the nucleus, but since Cyanobacteria have no nucleus, you can find its DNA in long strands. Using the sun's energy, Cyanobacteria produce oxygen in tiny bubbles. Cyanobacteria are such an old life form that they changed the Earth's early atmosphere, one tiny bubble at a time!

Diatom: A Diatom is a type of microbe that has a membrane around them that is called "glass." This surrounding membrane is not actual glass, but is clear and so looks like glass. Diatoms make their own food using the sun's energy and water.

Hydrogen Sulfide: Hydrogen Sulfide is a colorless, flammable, poisonous gas that smells like rotten eggs.

Microbial Mat: A Microbial Mat is a place where several different types of microorganisms (microbes, or tiny single-celled animals) live together in a community. The mat is a tiny, multi-layered community where each microbe produces something (oxygen, food, etc.) that is useful to the other microbes in the mat. It is completely self-sustaining, meaning that the microbes don't need any outside food or air to live. They only need water. Because the microbes are some of the very first types of life that formed on Earth, finding Microbial Mats on other planets could indicate that life existed at one time on those planets!

Purple Sulfur Bacteria: Purple Sulfur Bacteria use infrared radiation and hydrogen sulfide (that's what makes things smell like rotten eggs!) to perform a type of photosynthesis that doesn't produce oxygen, called anoxygenic photosynthesis. Instead, these bacteria produce sulfur!

Stromatolite: Stromatolite are rock-like layers of sand produced by microbes trapping, binding or releasing minerals.

Sulfate Reducing Bacteria: Sulfate Reducing Bacteria take the sulfur produced by the Purple Sulfur Bacteria and make hydrogen sulfide (which is what the Purple Sulfur Bacteria use!). They live in the very bottom of the Microbial Mat, away from all of the oxygen, because they can't survive with oxygen in their environment.

Microbial Mats (Part 2 of 2):

What is it?

Now that we have learned a little about what types of life is found in Microbial Mats, it's time to grow our own! In this activity, students will grow a Microbial Mat that they can take home or keep at school (see **Possible Extensions** section of this activity).

This activity discusses topics related to National Science Education Standards:

5-LS2-1: *Develop a model to describe the movement of matter among plants, animals, decomposers and the environment.*

- This activity helps students understand that a Microbial Mat is an interdependent ecosystem in which different organisms can only survive because of one another.

Materials (per team of 4 students):

Equipment, provided by NASA:

- Plastic container with lid
- 1 jumbo pipet

Equipment, not provided by NASA:

- Permanent marker
- Ruler
- Paper cup (for seawater)
- Scoop (for mud)

Consumables, provided by NASA:

- Microbial Mat Starter (FRAGILE! Please *To avoid gas building up inside of the Microbial Mat Starter container, please loosen the lid after returning to the classroom. Please tighten the lid before transport.*

Consumables, not provided by NASA:

- Sand
- Small amount of hard-boiled egg yolk (1 – 2 yolks should be enough for the class)
- Paper towels

Materials (per student):

Equipment, not provided by NASA:

- Safety Goggles
- Latex (or Latex-alternative) Gloves

Printables:

- Microbial Mat Worksheet
- *Glossary of Terms (optional)*

Artifact included in this kit:

- Fossilized Stromatolite Sample and Information Sheet

Recommended Speakers from Ames:
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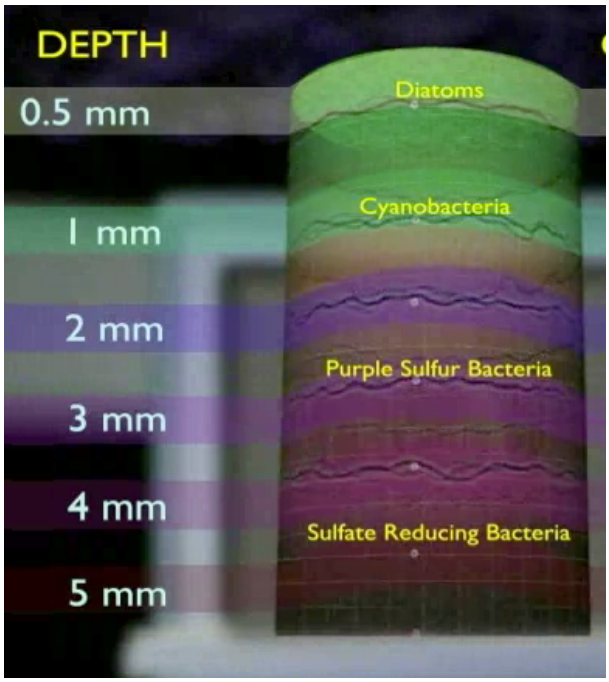
Darlene Lim (Limnology, Underwater Exploration, Astrobiology)

Set-Up Recommendations:

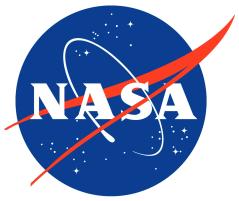
- Lay out materials for each team (square plastic container, pipet, ruler, permanent marker, paper cup, goggles, gloves)
- Prepare copies of **Microbial Mat Worksheet** for students
- *[Optional] Write the **Glossary of Terms** on the board and/or prepare copies for students*
- Lay out mud, sand, seawater and egg yolk at the front of the room
- Draw picture to right on the board or pass out copies



Safety:

- It is important to be safe when performing experiments! Please be sure that students roll up their sleeves as well as wear gloves and goggles at all times!
- Even though none of the materials are necessarily harmful, please be sure that students do not consume any of the materials in this activity!

Procedure:



1. Introduce the activity to students with a discussion. Scientists use samples here on Earth to try to figure out what life on other planets may be like. Now that we have learned about "Microbial Mats" in the *Stromatolite Explorer*, we will now build our own!
2. We recommend breaking up the class into teams of 4. Materials have been provided for teams of 4. More materials can be purchased for smaller teams/larger classes.
3. Pass out copies of the **Microbial Mat Worksheet**.

4. *[Optional] Pass out copies of the **Glossary of Terms**. We appreciate these terms are advanced, but feel that with proper explanation, students could start to understand their meaning.*
5. Together as a class, identify each of the tools in front of them (plastic container with lid, jumbo pipet, ruler, marker, cup, goggles, gloves). Have each student put on a pair of goggles and gloves.
6. **Safety Moment:** remind students that they MUST wear their gloves and goggles throughout the experiment. Also remind students that the materials they will be using are not to be consumed.
7. Ask students to remind themselves of the main parts of a Microbial Mat (from top to bottom): Diatoms, Cyanobacteria, Purple Sulfur Bacteria, and Sulfate Reducing Bacteria. All of the microbes are important for the survival of the rest.
8. Tell students you will begin at the bottom, with Sulfate Reducing Bacteria. First, you must add a carbon source, which is represented by paper towels. Have students add a few pieces of paper towels to the bottom of their container.
9. Sulfate Reducing Bacteria can be easily found in mud from a marine (ocean) environment! It doesn't need any light or any oxygen, and so it will grow in the bottom of the mud layer. Have a representative from each team come up and collect some mud from the front of the room and place it in the bottom of their container.
10. The main ingredient needed in the mud is cyanos, but it may not have enough on its own. Have students come up and collect a small amount (1/2 teaspoon) of Cyanomix from the front of the room and sprinkle on top of the mud.
11. Purple Sulfur Bacteria can also be found in mud, but unlike Sulfate Reducing Bacteria, it needs light to grow. It also needs sulfate, which can be found in egg yolk! Have students come up and collect a small amount of egg yolk. Sprinkle the egg yolk on the top of the mud.
12. Even though Purple Sulfur Bacteria need light to grow, oxygen is poisonous to them and so a layer of sand must protect it. Have each student come up to the front of the room to collect some sand and put a thin layer of sand on top of their mud and egg yolk.

13. Cyanobacteria and Diatoms can be found in seawater. The seawater also provides a lot of nutrients for the microbes to grow. Have students come up and collect a small amount of seawater (about 40mL – 50mL should be plenty) using the jumbo pipet and have them *gently* pour it into their container. We suggest the water is poured down the sides of the container, so as to not disturb the layers they have just created.
14. Now, students have all of the building blocks for a Microbial Mat. Have them shut the lid. Each team should now draw a line where the water level is on their container. If needed over the next several weeks, have students fill their container with more water (distilled, spring or tap that has set out for a long so that it has lost any chlorine that may be in it) up to the water line.
15. Have students answer the question on their **Microbial Mat Worksheet**. In several weeks, if kept in a warm and bright place, they will begin to see changes inside of the container! Their Microbial Mat is growing, and the bacteria inside are working together for a balanced micro-ecosystem!
16. [Possible Extension:] Every week for the following 3 weeks, have students make and record observations about their Microbial Mat. Use tools like rulers, magnifying glasses, etc. to gather as much information is possible. Ask questions like, “Why is that changing color? What do you think is going on in there?” to try to encourage critical thinking.

Helpful Resources:

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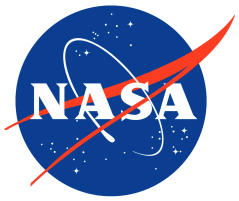
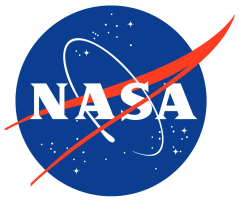


Name: _____

Microbial Mat Worksheet

1. Draw an image of your Microbial Mat and label it using the following word list:

Sand	Cyanobacteria
Diatom	Seawater
Egg Yolk	Purple Sulfur Bacteria
Air	Sulfur Reducing Bacteria



Glossary of Terms

Cyanobacteria: Cyanobacteria are photosynthetic (uses sunlight for energy) microbes that do not have a nucleus (like normal cells). In normal cells, DNA can be found wound tightly inside of the nucleus, but since Cyanobacteria have no nucleus, you can find its DNA in long strands. Using the sun's energy, Cyanobacteria produce oxygen in tiny bubbles. Cyanobacteria are such an old life form that they changed the Earth's early atmosphere, one tiny bubble at a time!

Diatom: A Diatom is a type of microbe that has a wall around them that is called a "frustule, " which is actually made of a glass-like material. Diatoms make their own food using the sun's energy and water.

Hydrogen Sulfide: Hydrogen Sulfide is a colorless, flammable, poisonous gas that smells like rotten eggs.

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Stromatolite: Stromatolites are rock-like layers of sand produced by microbes trapping, binding or releasing minerals. Microbial Mats are the types of microbial communities that most often produce stromatolites.

Sulfate Reducing Bacteria: Sulfate Reducing Bacteria make hydrogen sulfide (which is what the Purple Sulfur Bacteria use!) from the sulfate in seawater. They live in the very bottom of the Microbial Mat, away from all of the oxygen, because they can't survive with oxygen in their environment.